SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, SEPTEMBER 28, 1906.

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SOME PROBLEMS FOR AGRICULTURAL CHEMISTS.[1]

THE topic of my paper is not intended to convey the idea that I have anything new or startling to suggest, or that I intend to point out the shortcomings of the American agricultural chemist. My purpose is mainly to state what an experience of twenty-five years has suggested in the way of chemical investigations that seem now to be essential, if we are to maintain, or increase, the fertility of our soils, and thus retain the position that we have acquired as an agricultural people. We have in this country quite as capable chemists, I am sure, as there are in any country, yet the conditions existing here in the past, and that do exist now, in a way, have been such as to demand that our agricultural chemists should follow lines of a semi-technical, rather than of an investigational, character, in the sense that they have necessarily applied themselves to the problems of crop utilization, rather than to those having to do with the principles involved in their production. The principles of agricultural chemistry, which the early investigators established, and which were collated and formed into a science by the aid of the immortal Liebig, have served as the foundation for our work, and this basis has been sufficient to enable us to make great progress from the economic standpoint, so long as there were, in a sense, new worlds to conquer and new

[1] An address delivered before the American Chemical Society at the Ithaca meeting.

fields to cultivate, but do not fully serve when the rich stores of fertility in our fields have been, in part, exhausted.

In the next place, the conditions that existed here in the earlier history of our country, were not such as to demand on the part of the tiller of the soil, or farmer, a knowledge of those principles which would enable him to utilize to the best advantage soil fertility, and when the time came (as it has now for a large portion of our country), when knowledge of principles became a necessity, in order that farming on these areas might be made profitable, the first duty of the chemist was to rather demonstrate the usefulness of an application of the chemical knowledge already available. That is, the chemist became a teacher, rather than an investigator, and the results of his work have been altogether good. There is now a wide knowledge of underlying principles, among the more intelligent of our farmers, mainly, however, in respect to what we now know of the relationship between the soil, the plant and the animal. The farmer has been taught that the soil is potentially fertile, in proportion to the amount of nitrogen, phosphorus and potassium that it contains; that the removal of crops, resulting in the carrying away of these essential elements, will ultimately exhaust his soil to such an extent as to make their further growth unprofitable, without the addition of the other elements. He has, also, learned from the chemist that a judicious utilization of crops upon the farm, and a careful handling and use of waste products, will extend the period of profitable cropping. The chemists of the country have, also, rendered incalculable service in the study of those substances which carry these elements of fertility, and which are capable of serving as food for plants, and thus developing in a remarkable degree the farmer's ability to use them in the manufacture of crops, in the sense that they may be converted into products of high commercial value. The chemists have, also, promoted the intelligent purchase and use of commercial fertilizers, by the development and improvement of methods of chemical analysis, which enable them to accurately determine the various chemical forms. They have, also, by means of field experiments, demonstrated their comparative influence in meeting soil and crop requirements, and are thus able to give safe advice as to the value of the various supplies.

Still, with all this, and with the utilization of the products in the best manner, we are confronted with the fact that we have but little more definite knowledge of the soil and the principles involved in its treatment than we had sixty years ago. Fertility is not nitrogen, phosphorus and potassium alone, though the potential value of any field, or state or country, from the agricultural standpoint, is measured by these constituent elements in its soil, yet it has been demonstrated that soils which contain an abundance of these elements, and which are potentially capable of producing crops for centuries perhaps, are not capable of producing profitable crops without the addition of further amounts of these constituents. The chemical investigator is, therefore, obliged to take into consideration other facts than this. He must, if he would cover the whole field, know something of geology, of botany, of physics, of biology, of bacteriology and of the other natural sciences, because chemistry alone is not capable of fully compassing the problem, thus the opportunity for specializing in any branch has been very great, and it is because of the broadness of the subject, and the opportunity, as already pointed out, and the necessity,

also, for giving immediate help from the knowledge that we have that has prevented in a degree a broad study of the fundamentals essential for enabling genuine progress to be made.

What are, therefore, some of the questions that now confront us, as chemists, and the solutions of which have so important a bearing upon the agricultural progress, and consequent true development and utilization of our resources? One of the first questions which, it seems to me, is important, is the question of the ultimate effect of the continued use of commercial fertilizers. The problem is before us now. Frequently, questions come which we can not answer. For example, the farmer who has used large quantities of commercial fertilizers for the growing of early potatoes, cabbage, celery, or any other crop of this class, states that his crops do not seem to respond to these applications in the same degree as formerly, and that increasing quantities are required to secure profitable results, notwithstanding calculations show a great accumulation of these elements in the soil. Furthermore, he has, also, learned that other crops in the rotation do not thrive as well as formerly. He can distinguish no marked difference in the character of his soil, but clover, alfalfa, beans or peas, do not grow as well as formerly. He is unable by a judicious seeding of crops, for supplying vegetable matter, to secure a normal and healthy growth. Hence, questions as to the cause of the trouble are asked of the chemist, but can not be answered fully by him. He is unable to point out the cause of the difficulty; he may suggest that the result is due to changes in the physical character of the soil, due to the undue removal of one or more element, not included in the commercial fertilizers applied; to the destruction of certain forms of bacteria, or to the development of plant poisons in the soil, but he has nothing definite to offer. Hence, it seems to me that this is an important problem for our chemists to solve, and which must be solved if we are to make progress, and to give to the farmer what he is justly entitled to, for have we not advised him, by our teachings, to follow the methods which he is now using, without warning as to the possible effect of his work? This condition of affairs applies more particularly to those sections of our country where the lands were not originally abundantly supplied with the essential elements. The areas now requiring large applications of commercial fertilizers are fortunately limited in this rich country of ours, yet they are so located in reference to markets as to make them increasingly valuable. In the richer sections, too, farmers are learning, by sad experience, that the productivity of their soils is not as great as formerly; they know now that their methods of farming have been wasteful, and that the available constituents have, in large part, been removed, yet they have been taught by the chemists that there exists in their soils such an abundance of the minerals as to make it possible to grow maximum crops for centuries, though they are unable, with the knowledge now available to them, to obtain as large crops as formerly, without the application of fertilizers. These areas are so large, that it is manifestly impossible, with the supplies of material in sight, to provide artificial fertilizers, in order to meet the situation; neither is such a practise warranted, with the vast quantities now present in the surface and subsoils. The chemist advises that it is probably a question of imperfect chemical, or physical, or bacteriological conditions of the soil, or of all these combined. The chemist should not deal in probabilities; he

should be able to give positive advice. Hence, this is a problem for the chemist, and one worthy of his best thought—he must find out what the cause of apparent exhaustion is, and he should be able to show the farmer what his sources of loss are and be able to suggest a remedy. It has been shown by many experiments that in the ordinary and common methods of farm practise, there is a loss of the important element nitrogen, from the soil, greater than that accounted for by the removal of crops, and, furthermore, that the judicious application of commercial fertilizer or of yard manures does not result in proportionately increasing, or even maintaining the content of nitrogen in such soils. The chemist, with his present knowledge, advises that the loss may be due to either of three causes, or of one or more combined, viz., percolation into the drains, oxidation, or denitrification, but they are unable to suggest a method of practise which will remove the cause of loss. This is a problem of the first importance, the solution of which must rest with the chemist.

It is true that one phase of the nitrogen problem has been solved, but it has reference to the possible gain of nitrogen to soils, and thus in a sense compensates for the losses, though it makes the question of losses none the less important. I have reference, now, to discoveries that have been made, in regard to the symbiotic action of certain bacteria, which give to the leguminous plants their power of absorbing nitrogen from the air, and dispose of the question, in the sense that so long as the farmer judiciously uses any one of this class of crops in his rotation, it will be possible for him to, not only maintain, but to even increase the nitrogen content of his soils, and thus make the question of exhaustion from that standpoint one not to be feared. It seems to me, however, that we have but reached the threshold in these investigations, for while as a matter of fact such a practise will result in adding this important element to the soil, it does not dispose of the question of the full utilization of the nitrogen acquired. We have many instances of attempts made to improve soils, or to maintain their fertility by the introduction of leguminous crops, which have proved disastrous, rather than helpful, in promoting plant growth, or of permanently increasing fertility in this respect. Furthermore, we have no definite knowledge as yet, as to the conditions which are necessary in order that the plants shall appropriate nitrogen from the air, rather than from the soil, nor have we any definite information as to how large a proportion of the nitrogen so gathered is retained in the soil for the use of cereal and other crops which depend entirely upon soil sources for their nitrogen. I feel certain that no agricultural chemist of the present day would dare to risk his reputation on a positive statement, in reference to any one of these phases of the question. The nitrogen question in agriculture is far-reaching in its influence, affecting not only those who cultivate the soil, but those who depend upon its products for their sustenance and profit; it is a question which has occupied the student of chemistry from the earliest times, and the various theories advanced have caused no end of controversy among them, yet in many of its phases it is still a problem to be solved.

Another question, closely associated with this one of nitrogen, if not intimately connected therewith, is that of the importance of humus in relation to fertility. It has been recently stated by an eminent experiment station director that 'the mineral elements form but the skeleton of the

soil, and without humus, which gives life and activity are practically useless as a medium for plant growth.' This statement is an attractive one, and may be in a broad sense correct, but, notwithstanding all of the investigations that have been made, I am of the opinion that much has yet to be learned as to the function of humus and the influence it exerts in the maintaining and improving of the fertility of our soils. We are unable from our present knowledge to state whether the effect is physical, chemical or biological, or whether it is a combined effect of each, or whether it is absolutely essential that the organic matter be present in large amounts, in order that the best results may be obtained. It is a problem well worthy of the attention of our agricultural chemists, and one which must be solved, if we are to give safe advice as to the cultivation of our soils.

Still another problem, which is agitating the minds of many far-seeing investigators, is the question of the supplies of artificial plant-food, aside from that involved in the question of nitrogen. As already pointed out, it has been clearly demonstrated that so far as the mineral elements are concerned, there is sufficient in the soils of this country to supply the needs of maximum crops for centuries, but this statement must be modified, so as to read 'sufficient to supply the needs of general crops, cereals and grasses, or any other crop which in its cultivation is allowed to develop under natural conditions,' but it does not apply to that class of crops, the need of which is increasing rapidly, that can not be grown to perfection in such quantities as to meet the demands of a modern civilization, without the stimulating effect of immediately available plant-food. I now refer to the large number of vegetable crops, fruits, berries, etc., which must be produced under semi-artificial conditions, in order that they may possess those characteristics of quality, and be provided at such times as the present demands require. There will, therefore, be a constantly increasing demand for plant-food, which can not be supplied by natural means, including the use of home-made manures.

The nitrogen question, as already pointed out, has received the attention of eminent investigators, and the problem has been solved in so far as the actual obtaining of free nitrogen from atmospheric sources, both by means of special classes of crops and by chemical combination. How soon the latter may be a practical source is still a question, but the progress thus far made indicates that the solution will be reached in the near future. There is, however, still a broad field for study, as to the source of supply of phosphates and of potash salts. We have in this country, and in Canada, enormous deposits of phosphate rock, already exploited; others will undoubtedly be found, so that the question is not one that requires such immediate attention. Nevertheless, with the great demands which are likely to be made, it is one well worthy of the study of our chemists. In the case of potash, we have no source of supply, at present, other than the Stassfurt mines of Germany, and the time must come, sooner or later, when these will not be able to meet the demand. Whether the potash stored in our granite hills are to supply these demands, or whether unknown deposits exist in our country, are questions that must occupy the minds of our agricultural chemists, and are problems which are of fundamental importance, because they have to do, not only with the production of crops, but with the future progress of humanity.

Still another question, or problem, which it seems to me the chemist should solve,

is rather of economic importance than of pure science, since it has to do with the transfer of the plant-food elements from one place to another, and their loss, in so far as our own country is concerned. It is a problem which has been but lightly touched upon, though many have recognized its significance. We are exporting in whole grains, and in waste materials from our oil and starch factories, enormous quantities of human and animal foods, for which we receive a return only in proportion to nutritive values, whereas these products carry enormous quantities of constituents from our country. The problem here, as already stated, is not a problem so much of investigation as it is an exploitation of the facts, and the education of the people as to the possible ultimate effect. The agricultural chemist must stand as the conservator of the nation's wealth; he is the one whom others seek for definite information, and for guidance, and it is his business to so direct the attention of the people as to prevent an undue loss of our fertility elements.

There is no doubt but that by careful adjustments of trade conditions it will be possible to obtain quite as much money for our surplus products as is obtained at the present time, without having the practise result in so great an annual loss of our plant-food constituents. The problem is not an easy one to solve, though I am sure that with the earnest study and support of our agricultural chemists, it will be solved in a manner that will result in the best good to all. It is an important question, and one which I hope our chemists will regard as worthy of their study.

I am well aware that in this brief paper, which was purposely made general in its character, I have done little more than to point out some of the reasons why the conditions have not been favorable thus far for such work as seems now to be needed, and to suggest lines of investigation, without being specific as to the methods by which they should be carried out. Nevertheless, the few facts stated are patent to all who have given the subject thought, and are sufficient to indicate the importance of a broad and detailed study of the whole question of soil fertility. The field is now largely unoccupied, and there is a growing demand for broadly trained investigators, and there is no field of investigation more promising of fruitful results for the investigator and the country at large. Our professors of chemistry and our colleges and universities should cooperate in providing such opportunities for study as shall fit them to pursue this attractive and important line of investigation.

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THE TEACHING OF SCIENCE IN COLLEGE.[1]

I wish to call attention to a situation which seems to me unnatural and unfortunate. It is unnecessary to present it in statistical form. No one will question that science in the colleges of this and other universities has not the importance and popularity that it should have, that this element of our modern education is by no means represented in the results of education in accordance with its importance.

It is not, however, to the failure to elect scientific courses as they are to-day or to enroll themselves for science degrees on the part of our students that I think especial attention should be directed. Nor do I think that we can explain this and other evidences of the deficiencies in this regard by the traditional prestige of the so-called humanities, or the prejudicing of the stu-

[1] Address delivered before the Chicago Chapter Sigma Chi, March, 1906.

dents' minds by preparatory courses inimical to scientific interest.

Scientific courses have not become popular as the old requirements in the languages have been decreased. It is rather the other courses such as the Ph.B. that have profited by the greater freedom of election. With considerable freedom of election in the preparatory schools the scientific courses are not sought out there by the children at a period when the concrete subject-matter of science properly presented should be immensely more attractive than the languages and many more abstract objects of study. The science courses in the high school are not at the present time popular, nor is the money spent upon them, either in equipment or in teaching force, comparable with their educational importance.

The result of this is that the majority of our students leave our colleges and universities, without being able to grasp the most important achievements in modern thought, without being able to take the point of view of those thinkers who are reconstructing our views of the physical universe and its constituent parts, and without being able to interpret what they see and hear and feel by means of the profoundest and most magnificent generalizations which the world has ever known.

I wish to present two reasons for this condition which seem to me more fundamental than those usually presented, and to discuss in connection with them the possibility of removing them or at least to invite discussion on the subject.

It is natural to compare the sciences so-called with the humanities. And yet in one respect the distinction between them has much decreased of late years and promises to continue to decrease. The method of study of the languages, history, literature and the so-called social sciences has become to a large degree that of the natural sciences. There is certainly no fundamental distinction between the researches of the historian, the philologist, the social statistician and those of the biologist, the geologist or even the physicist and chemist, in point of method. Each is approaching problems which must be solved, and to be solved must be presented in the form of carefully gathered data. For their solution hypotheses must be constructed and tested by means of experiment or observation. With the complexity of the phenomena, of course, the application of the scientific methods will vary. The processes of observation, for example, will vary enormously in the study of a historical problem in the ancient world, and in the study of the problem of variation where the material is immediately at hand. The methods of historical criticism—lower and higher—are nothing but methods of observations under conditions which are peculiarly difficult of access.

While it is true that in literature and other arts we do not go back of the esthetic reaction in the judgment of beauty, or the study of this reaction in others as presented in literary criticism; outside this field of appreciation and criticism, the methods of study in the field of the humanities is just as scientific as the subject matter with which it deals allows.

This means for one thing that we no longer regard the acquirement of information as the legitimate object or method of education. The ideal of modern education is the solution of problems, the research method. And this research method is no less dominant in the humanities than it is in the natural sciences so far as the subject matter permits.

The ground for the difference in attractive power of the natural sciences and the humanities can not be laid up, therefore, to a difference in method. And if it could the prospect would be discouraging indeed

and the judgment upon the students most unflattering, for the research method is, after all, nothing but the elaboration of the simple processes of perceiving and conceiving the world, elaborated in such a way that it can be applied to the complex and subtle problems of the physicist, the geologist, the biologist, etc. If the scientific method were the cause of unpopularity we should have to assume that the process of knowledge itself, the very function of cognition, was disagreeable to the average student.

If, however, we examine these two types of studies we do meet a distinction which holds for many if not for all. In the physical sciences the process of investigation involves the analysis of the objects, which are studied, into elements which are not present to immediate experience and which are with difficulty conceived and presented to the mind. The resolution of nature into atoms and molecules or corpuscles is an undertaking presenting itself at the beginning of scientific investigation, that is not forced upon the social sciences. Here the elements into which analysis reduces its objects are at bottom, but more or less reproducible states of our own consciousness, or still more direct objects of possible sense-perception. This was a difficulty that did not inhere in the old-time natural history. There the problem that aroused investigation was stated in terms of everyday experience, and for this very reason natural history was a more successful subject in the curriculum than our physics and chemistry. Its problems were real problems in the minds of the students. They were not located in a field as yet foreign to their acquaintance and, therefore, artificial and unmeaning.

The problems of biology and geology do not suffer as much from this remoteness, for to a large degree they can be stated in terms of a possible immediate experience of the student, and it is true that they make a more immediate appeal to the student than do the physical sciences. But it must not be forgotten that these biological and geological sciences are to no small degree applied physics and chemistry, and that this tendency is steadily increasing. That is, it is increasingly difficult to state the problems of these sciences in terms of immediate experience; their problems do not arise of themselves in the consciousness of the student, in other words, he is not immediately interested in the study.

We can generalize this in the following form: the result of the development of our sciences has been that their problems are no longer within the immediate experience of the student, nor are they always statable in terms of that experience. He has to be introduced to the science before he can reach the source of interest, *i. e.*, problems which are his own and which he wants to solve by the process of his own thinking.

On the whole, the problems of the social sciences have a meaning to the student when he meets them, *i. e.*, they can be his own problems from the start, and they do not have to be translated into terms which must be somewhat painfully acquired before they can be used.

In a certain sense mathematics has become the language of the physical sciences, and the student must have a command of this vernacular before he can read with interest that which is writ in the sciences, before he can attack their problems. But even where the vernacular of the science is not that of mathematics, it is still true, to a large extent, that the field of the real problems in the science lies outside of the direct experience of the student.

It hangs together with this, in the second place, that the natural sciences are not interconnected in the minds of the students, that they exist in water-tight compartments. There is no common field out of which they all spring. It seems to me that

in this lies the great advantage which the humanities so-called have over the natural sciences in the curriculum. They all of them belong to one piece of human experience, and it remains true *nil humanum mihi alienum est,* not simply because of the immediate human sympathy which unites men and women who are distant not only in space, but also in time, not only in speech, but also in state of civilization; there is a still more important hold which the social sciences and humanities have upon the interest of the student. It is that human history, human development, human institutions, its arts, its literature, its achievements, are so bound up together with each other, with the languages in which thought has been expressed, with the literature in which achievements have been recorded, with the movements of trade, commerce, colonization and discovery which have motived historic changes, that wherever one begins, problems of all sorts arise at once, interlacing with each other, so that the pursuit of one subject reinforces the interest in another, and *vice versa.* The whole group represents one social world which can not be picked up piecemeal nor divided up into separate compartments, but is bound to exist in the mind as a whole.

This is not simply an advantage of an external sort. The logician tells us that, if we would expand it, the subject of every judgment would be found to be the universe itself, individualized in some immediate experience, but implying the whole world in its implicit relations. If we express this somewhat more modestly it would run, in educational terms, that it is only the implicit relation to other things that makes any subject teachable or learnable, and that the more evident and more pregnant these relations are the more readily is it assimilated. In a certain sense the more complex a thing is the more readily it is acquired, while its simplicity leaves it bare, without lines of connection, without retaining points. Of course this would not be the case if education were merely a process of storing away, a process of piling learning into the mind. But as the theory of science instruction, as well as scientific advance, is that of research, it is evident that the richer an object is in relation to other things the more suggestive it will be of solutions for problems, the more fertile it will be in arousing associations of kindred data. To bring out a problem then in a field which is already rich in interest is to insure not only its immediate attractiveness, but to provide the ideas and connections through which the problem may be studied and a solution reached.

It is this wealth of associations, this complex interrelation with a mass of other things, which the student fails to secure when he is introduced to modern science, through one door at a time, and that door leading into a specialized subject-matter whose relations with immediate experience are of the slightest character. A new subject should not be presented by itself, but in its relation to other things. It must grow in some fashion out of the student's present world.

The problem of college science is, therefore, very intimately connected with science in the secondary school. If the child were introduced to it in the proper way there the situation, which has just been described, would not exist in the college. He would come up into the college with the world of science already in existence, and that world as a field of his own experience. He would find problems arising there for whose solution he must look to the more specialized sciences. But the opposite of this is the case. Science in the high school, at the present time, is in a more parlous condition than it is in the college, because the child is farther away from the field of exact science

than in the later college years. He finds fewer points of connection. His sciences remain for him located between impassable barriers. The college, therefore, at least until a reform can be wrought in the secondary school, is forced to face the problem within its own walls.

Its solution calls for introductory courses which will lead the student into the field of science, which will show the problems of his own experience in terms of this new field, and show them there capable of solution. There are two points of view from which such courses could be naturally presented; that of history, and that of a survey of the world analogous to what is given in introductory courses in sociology or social institutions.

The peculiar appropriateness of a course in the history of science for the junior college students, lies in the fact that the special character of modern science would grow out of the conditions that made it natural and necessary. There would be in it the inspiration of the personalities of the great scientific men, and the romance of their struggle with difficulties which beset their sciences from within and without. The conceptions of to-day would be found motived in the struggles of yesterday. But still more important the relations which have subsisted between scientific investigation and the whole field of human endeavor would appear—its relation to commerce, industry, the geographical distribution of men, their interconnection with each other, and the other sides of their intellectual life. Science would be interwoven with the whole human world of which it is actually a part. It is true that something of this is found in general history. It is there, however, presented not to lead up to further study of science, but to merely fill out the entire picture—a picture which is so crowded that many features are bound to be slighted, and among those which are slighted, science, just because it is a subject somewhat apart, is sure to be found.

We have of course the evidence of the import which such a course would have in the biographies of our scientific men—such as Darwin, Huxley, Pasteur, von Helmholtz. But few of our students in that period read them, and taken by themselves they do not have the educative power which the story of their efforts would have when presented in a course on the history of science. It is not, however, principally the personal note, which comes from the account of the men who have been the heroes of science, that would be found in such study. It is rather the form in which the scientific problem arose and the methods used for its solution which will carry the most valuable instruction. One scientific theory swallows up into itself what has preceded it, and the traces of the situation out of which the later doctrine arose are washed away. While our historical atlases present us in flaring colors the political situations out of which sprang present political conformations, the young student of science must pick up, as best he may, without assistance or interpretation, the explanation and historical interpretation of the conceptions he is forced to use. If an adequate comprehension of the powers of the American executive can not be gained without a knowledge of the situation which preceded the formation of the constitution, no more can the uninstructed student comprehend the value of such terms as forces, energies, variations, atoms or molecules without understanding what the problems were which brought forth these hypotheses and scientific conceptions.

And there is no study like that of history to bring out the solidarity of human thought. The interdependence of scientific effort and achievement, and the interrelationship which exists between all science in presenting its world as a whole, can be

brought out vividly only when its history is being presented, while in the midst of the arduous struggle with a single science these profound connections are quite overlooked. It is a fact that science is, from an important point of view, a single body of knowledge, whose different parts determine each other mutually, though this mutual influence is often overlooked. When the historian comes forward with the picture of a past age, such as Gompertz has given us in his 'Grieschische Denker,' we recognize these interconnections and see that what has been done in one line has been now advanced because of the achievement of another, and now has been thwarted by the backwardness in still another. The Weltanshauung of any age is at once the result of all its scientific achievements and a cause of each, by itself. We can not finally understand any one without the comprehension of the whole, and it is the whole which is more comprehensible than any single science. It is a great deal easier to present the problem of evolution in the world as a whole than it is in the specific instance. It is easier to recognize the problem of matter, as it is presented in the book entitled 'The New Knowledge,' than it is to present the specific problem with which the physicist or chemist must wrestle. It may be a Hegelism, but it is good educational doctrine that the whole is more concrete than the part. A student who has first followed out the results of scientific evolution through the preceding centuries in their interconnection with each other, and meets then the problems of modern science as the growing points of the past, who understands somewhat what the controlling meanings are behind scientific concepts and terminology, who feels that he is entering into a battle that is going on, whose field he has surveyed before he has lost himself in the particular brigade, such a student is bound to enter into his study with both a comprehension and an interest which his brother will lack —his brother who must get the parts before he can have an inkling of the whole.

I am aware that, in the minds of a great many of you, there has arisen a spirit of contradiction to what has been presented, a spirit of contradiction which arises out of the very competency and exactness of the scientist. Such a type of instruction as that suggested above is felt to be superficial, inexact, and bound to be misleading to the person who is not scientifically trained. It would be information in a word, and the scientist does not hold it to be his position to impart information, nor can he promise any valuable educational result from a course whose content is one of information.

I wish to bring out the point because it seems to me fundamental to the question which has been broached. We need, in the first place, a definition of what information is and what knowledge is, as distinguished from it. I would suggest toward such a definition that nothing is information which helps any one to understand better a question he is trying to answer, a problem he is trying to solve. Whatever bridges over a gap in a student's mind, enabling him to present concretely what otherwise would have been an abstract symbol, is knowledge and not mere information. Whatever is stored up, without immediate need, for some later occasion, for display or to pass examinations is mere information, and has no enduring place in the mind. From this standpoint nothing is superficial or inexact which gives concreteness and meaning to the problem before the student. Truth is a relative thing. We none of us have exact knowledge in the sense that our knowledge is exhaustive, and we none of us know the full import of what we do grasp. There can be no objection to the young student having a broad if seemingly superficial view of the scientific world, if it helps him to approach with

more understanding the particular science he has before him. It is also certainly the pedagogic duty of the instructor in science to get far enough into the consciousness of the student to present the part to him by means of the whole.

The second point of view suggested for approach to the specialized study of science was that of the survey of the present field. If we can find the counterparts of the historical course in the biographies of great scientists, we can find that of the survey course in such treatises as the popular lectures of eminent scientists, such as those of Tyndall on 'Sound,' or many of the popular lectures of men like von Helmholtz, du Bois Reymond and a score of others. We highly approve of such lectures when they appear on the lyceum or the university extension platform. We encourage the reading of such books, considering them distinctly educative, but we deny that they have a place in the university curriculum. The prevailing assumption is that when one can not follow out the scientific process by which the results are reached, it is indeed better that he should have the result presented in a form which he can understand than not to have them at all, though it is not the place of the university to perform this function, except through its extension department. This statement, however, overlooks the fact that such acquaintance with the results of scientific research is also the source of interest in the research itself. What is merely keeping up with the progress of the world on the part of the business man is preparation for the student who has to approach a new field. I presume that no one would question that those who had listened with intense interest and enthusiasm to an extension lecture upon the solar system would be better prepared for the study of astronomy. Indeed, we assume that university extension will serve in this fashion as a feeder of the university, but for some reason we feel that this same sort of preparatory work has no place inside of the university itself. From the point of view of education we are mistaken, for nothing is out of place which makes the approach of the students to the subject-matter a normal one. And until the student feels the problem of the science he undertakes to be a problem of his own, springing out of his own thought and experience, his approach is not a normal one.

One or two courses, then, from the standpoint of the history of science, and from that of the survey of the scientific field of to-day in the junior college, would organize the vague information of the student, would correlate it with the political and literary history with which he is familiar, would give him the sense of growth and vitality, would state the problems of science in his own terms, and awaken in him the passion to carry on the investigation himself which might otherwise remain dormant. They would be feeders to the specialized scientific courses that follow. They would break down the prejudice which most students bring against science from the high school. But not least, they would be as educative as any course in history could possibly be. They would serve as valuable a function as those courses which aim to acquaint the student with the social and political forces which dominate the world into which he is to enter.

What has been said so far has borne directly upon introductory courses in the junior college. It is only in the last remark that I have touched upon the demands which the university may make upon its scientists for the interpretation of the world for those who do not follow its special courses. If in the present day, under the sign of science in nature and society, any one leaves an institution of higher learning without a comprehension of the results of science, which he can grasp

in their relationship to the rest of human history and endeavor, he is certainly cheated out of one of the most valuable of the endowments which he has a right to demand from that institution. As I have already indicated, scientific method is dominant not only in the study of nature, but in the study of all the social subject-matters, in religion, politics, in all social institutions. Scientific discoveries have made over the answer even to the fundamental question of who is my neighbor. Science is responsible for the view of the universe as a whole which must be the background of our theology as well as our philosophy and much that is finest in our literature. Science has changed sentiment to intelligence in divine charity, and has substituted the virtue of reformation of evil for that of resignation thereto in religion. And yet a large percentage of our students leave the university without having any better opportunity of coming to close quarters with this science than those who are outside the university. They are compelled to get their science from the extension platform, or from the popular magazine. There should be unspecialized science for those who do not specialize in science, because they have the right to demand it of an educational institution.

There is still another demand that should be made upon the science faculties of the university, and that is that they should so organize the courses which their students take, that they will get the unity which every college course ought to give.

That unity of the social sciences which is given in subject-matter and human nature itself, is, as has been pointed out, absent from modern sciences which have become largely what Professor Wundt calls conceptual sciences. The interconnections are not apparent to the students who are in the special groups. Their attention is fixed within too narrow boundaries, the demands of their own subject is so great that they have no time to go beyond. They have a wealth which they can not realize because they can not put it into circulation.

Through the history of science, especially of the other sciences which they do not specialize in, through lecture courses which give them the results of these other sciences they should be able to get the unity of Weltanschauung, which is requisite for any college course.

It is requisite at the end as at the beginning that the student should see his world as a whole, should take up into it what he has acquired, and should get the mutual interpretation which the relation of his subject-matter has to what lies beyond it.

There is certainly no agent that can carry more profound culture than the sciences, but our science curriculum is poor in what may be called culture courses in the sciences, and the import of science for culture has been but slightly recognized and but parsimoniously fostered.

GEORGE H. MEAD.

SCIENTIFIC BOOKS.

An Introduction to Astronomy. By FOREST RAY MOULTON, Ph.D., Assistant Professor of Astronomy in the University of Chicago. New York, The Macmillan Co. 1906. 8vo. Pp. xiii+557; 201 figures, including 50 photographic illustrations. $1.25.

This book is an elementary, descriptive text, suited to those who are approaching the subject for the first time, and from this point of view the selection of material is quite satisfactory, though not always presented in logical order. At the outset Professor Moulton gives a preliminary outline of the entire subject, followed by chapters which treat in greater detail of the topics usually considered in elementary works, such as systems of coordinates, the constellations, the classes and uses of astronomical instruments, and the leading facts and theories relating to the various bodies composing the solar and sidereal systems.

The book is designed to be readable even by those without extensive mathematical or scientific training; to give a general view of the results that astronomers have obtained in the course of their investigations; and to reveal something of that spirit which inspires scientific work. Astronomers to-day, perhaps more than ever before are endeavoring to solve great problems. The investigations leading to these ends are diverse, extended and many-sided, and the data drawn from the various sources often admit of widely different interpretations. In some departments advance comes from adhering to the hard and fast facts derived from exact measurements, in others from speculative inquiries based upon data that are more or less insecure, founded upon such observations as have been made to the present time. Often contradictory working hypotheses lie so near the limits of indetermination that one is as plausible as the other, and this is so in many of the problems of great human interest as they stand to-day. Hence it is not always easy to decide between rival hypotheses, for the overbalancing data favorable to one to-day may by fresh accessions to knowledge be turned to-morrow in favor of the other. In producing a work on astronomy for the general reader, and for the student as well, some attempt should be made to give that broadening view that the subject affords, not only by reason of its established facts but from the outlook afforded by investigations now in progress. The latter requires the inclusion of outlines of various theories still in formation, to be accepted or rejected according to the evidence that may be adduced in favor of or against them. In his 'Introduction to Astronomy,' Professor Moulton has many references to unsettled questions. He has always considered them with caution, giving briefly the arguments on both sides of debatable points, without commending to the reader one view rather than the other. The chapter on the evolution of the solar system, which may be regarded as the distinctive one of the book, deserves special mention, since it deals largely with the arguments tending to prove the general insufficiency of the Laplacian ring nebular hypothesis, which has so long held a place in elementary texts, and to the exposition of the new spiral nebular theory developed by Professors Chamberlain and Moulton. Even in reference to the latter the author cautions the reader against the too hasty acceptance of it as final, for much still remains to be accomplished in the way of quantitative determinations before this theory can take its place among the accepted results of science.

W. J. Hussey.

Ann Arbor, Michigan.

Introduction to General Inorganic Chemistry. By Alexander Smith. 8vo, pp. xviii + 780. New York, The Century Co. 1906.

This unusually excellent text-book is intended primarily for beginners in college courses. The author has wisely made the elucidation of chemical theory the main feature of the book, but the descriptive part has been well chosen for the purpose in view. Laboratory experiments are used as the basis of treatment, and the theories are thus explained in a very clear and satisfactory way. The subject is treated from the most modern standpoint, but this has been done without giving undue prominence to the newer theories.

An important feature of the book is found in the numerous references to previous pages, which enable the reader to refresh his memory in regard to matters already discussed. Other points attracting attention are a diagram showing the solubility curves of eighteen important salts, a table showing the actual and molar solubilities at 18° of more than a hundred salts, the use of the single or double arrow in place of the usual sign of equality in chemical equations, the introduction of many suggestive exercises or questions for students, and a serviceable index.

The course here presented is undoubtedly a long and difficult one for the average student, who relies mostly upon memory and possesses little or no power of reasoning; for it comprises practically the whole body of modern chemical theory, which is not grasped easily by the chemically vacant mind. However,

Professor Smith's work is certainly a good book for good students, and as such is to be heartily welcomed. H. L. WELLS.

SCIENTIFIC JOURNALS AND ARTICLES.

The Botanical Gazette for August contains the following papers: 'The Nascent Forest of the Miscou Beach Plain,' by W. F. Ganong, being the fourth contribution to the ecological plant geography of the province of New Brunswick; 'The Development and Anatomy of Sarracenia,' by Forrest Shreve; 'Physiologically Balanced Solutions for Plants,' by W. J. V. Osterhout; 'The Appressoria of the Anthracnoses,' by Heinrich Hasselbring; '*Nereocystis Luetkeana*,' by Theodore C. Frye, being a biological study of this giant kelp; 'New Species of Castilleja and Senecio,' by J. M. Greenman. The September number contains the following papers: 'Differentiation of Sex in Thallus Gametophytes and Sporophytes,' by A. F. Blakeslee, being a general discussion of sexuality in all the plant groups; 'The Development of the Bouteloua Formation,' by H. L. Shantz, being the second contribution from his study of the mesa region east of Pike's Peak; '*Cortinarius* a Mycorhiza-producing Fungus,' by C. H. Kaufmann, in which a new species of the genus is described that is connected with three forest symbionts belonging to different families; 'A New Fungus of Economic Importance,' by R. E. Smith and Elizabeth H. Smith, being a new genus (*Pythiacystis*) parasitic on lemons and causing a decay of green fruit trees and in the storehouse.

DISCUSSION AND CORRESPONDENCE.

DISCONTINUOUS VARIATION AND PEDIGREE CULTURE.

REFERRING to the recent address of Dr. D. T. MacDougal, on 'Discontinuous Variation and Pedigree Culture' (published in *The Popular Science Monthly* for September), the following points may be worth considering:

The species is the unit of the taxonomist, and the study of species and their relations to environment form the basis of the science of distribution.

The species, as thus considered, is a kind of animal or plant as it has developed and as it appears in a state of nature. To know a species as it appears is not to know it completely, as all species develop differently under changed conditions or freed from the stress of competition. Under domestication, or under new chemical or physical conditions, all species are plastic, and all may assume forms the same species can never assume in its original habitat.

The field naturalist can not therefore know everything about any species, no matter how many individuals he may examine. Neither can a garden naturalist, for the forms he deals with must be 'reduced to the ranks' before they are comparable to the species occurring in the wild.

It is presumable that those naturalists know most about species as they are, who have given most time and thought to their study. They may not, however, know better than any others how species originate, nor possess the clue to the main causes or significance of their varying forms.

Yet it is fair to say that as the taxonomist of species finds in practically every case a geographical element in the development; as he finds that segregation and selection have apparently been accompaniments of nearly all changes in species, and as by these same agencies all species can be appreciably changed by the will of man, he may not unreasonably suppose that segregation and selection have each taken some part in that life-adaptation which we call organic evolution.

As a zoologist personally acquainted with Dr. de Vries the writer has great reverence for the noble modesty, the patient, intelligent and epoch-making perseverance which have characterized his work. On the other hand, he is obliged to hesitate at the acceptance of the more sweeping parts of his theory, and to question the assumption that the discoveries of de Vries in plant mutation disclose the actual method of species-forming, general or universal, in all branches of life.

As matters are the species that exist in nature must furnish us our conception of species. The species actually covering the earth are

surely 'real' species, whether other forms called species are 'real' or not. We find no evidence that such species could not or do not originate, sometimes at least, through slight fluctuations acted upon by selection in segregation. We do not know that the effects of selection have any final limit except in certain cases where the limit is mechanical. It is not yet clearly shown that there is any real and fundamental difference between continuous and discontinuous variation, and most zoologists regard the conception and cycles of variation in the history of a species as an ingenious suggestion rather than as a part of science.

It is evident that there is much—very much—about animals and plants, which can be learned only from experimentation under changed conditions, as there is much that can not be known or even imagined without the aid of the microscope, and much that can not be known or imagined without the comparative study of many individuals and the comparison of faunal and floral areas. We must welcome the study of pedigreed individuals, animals or plants, as a most hopeful line of investigation, and it is certain that the discoveries it may yield can not be forestalled in advance. If they could the investigation would be unnecessary. So far as species are concerned, it is clear that a large part of the problem demands the study of the structure of forms and their relation to environment. There is much truth in Darwin's words that "One has hardly a right to examine the question of species who has not minutely described many."

As to the suggestion of the possible hybrid origin of Œnothera, the writer is not a botanist, and very much of botanical investigation escapes his notice. He is pleased to learn that the possibility of such origin on the part of *Œnothera lamarckiana* has been considered and fully disproved. A detailed account of the experiments which show this would be interesting. It would also be interesting to know the degree in which Burbank's hybrid walnuts of the second generation, showing 'every conceivable kind of variation,' conform to the Mendelian theory.

As to the theory that species are permanently changed by the direct impact of environment, which most faunal zoologists in America seem to accept, the writer thinks that Dr. MacDougal is probably right in claiming that "no evidence has yet been obtained to prove that the influence of tillage, cultivation or the mere pressure of environmental factors has produced any permanent changes in hereditary characters of unified strains of plants," or of animals either.

David Starr Jordan.

VULCANISM.

I have read the article of Elihu Thomson,[1] much of which is necessarily true, with considerable interest; but I doubt whether I can go so far as he does, partly because I have a pet theory of my own to nurture. What I miss in Thomson's article is some definite estimate or clear-cut specification of the actual conditions involved: how much stuff is moved; what work is spent; how much heat is generated. I have endeavored to picture the occurrences to myself in a cursory way for a normal case, somewhat as follows: The work done per cubic centimeter will in any distortion be half the product of the stress and the strain. This work will be elastically potentialized if the solid remains intact. If there is rupture it will appear as heat largely near the surface of separation. If it yields viscously (as is much the more probable) it will appear throughout the volume. The strain is probably a shear. The question at issue is then under what circumstances of torment must one shear a rock in order to melt it. Suppose we say the shear is one half, *i. e.*, if the tangential thrust is horizontal all initially vertical lines will be inclined thirty degrees; or in general there will be corresponding changes of inclination of thirty degrees, which seems to me to be enormous, but may, nevertheless, be admitted for the purpose of argument. We may then write, if the density of rock is 3, its specific heat .2, its igneous melting point as low as 1,000° C.,

$$\tfrac{1}{2} \times \tfrac{1}{2} \times F = 3 \times .2 \times 1000 \times 42 \times 10^6,$$

[1] Science, XXIV., p. 161, 1906.

to determine the tangential stress at F involved. It follows that $F = 10^{11}$ dynes/cm.^{2} or 10^5 kg./cm.^{2}; or since in a shear the tangential and the normal stresses are equal per square centimeter, about 100,000 atmospheres, even for the excessive strain in question. Now in a region where differential stresses of this value abound, the pressure itself must be at least of the same order, and hence if we compute such pressures hydrostatically (a case most favorable to shallowness of the seat of reaction) with ten feet of rock to the atmosphere, this would be equivalent to a depth below the surface of one million feet or 190 miles, where a shear of the value of one half is surely out of the question. Imagine the earth radii all flexed by this amount at their outer ends. Besides we are much too far down for practical vulcanism. Of course, we can get nearer the surface with bigger strains and smaller stresses, or we may imagine the energy of a fault all spilled upon the surface of rupture; but even in this case while the work done will depend on the volume displaced, it will also in a large measure be dissipated within that volume and by no means on the surface of separation alone.

The picture as a whole is not alluring because it is vague, to me at least, who am all the while fondling my own little notion. In fact I once came as near being a physical geologist as Elihu Thomson, though nobody seems to have found it out. Yet in the days when I still deluded myself into thinking such things interesting I happened upon an astonishing result in the endeavor to dissolve hot glass in hot water.[2] It did in fact dissolve to an eventually solid substance, which for hardness and optical character was not distinguishable superficially from the igneous glass; and it did this completely (in water, not in steam) at a temperature certainly much *below* 200° C. and in such a way (this is the point) that the system of igneous glass and liquid water contracted on combination as much as 20 or 30 per cent. of the initial total volume. Think of this; the contraction of concentrated sulphuric acid upon admixture with water is but 2 to 3 per cent., and even granting that molecular changes and not volume contractions are the truly important features, the case for water-glass can not be so easily dismissed. Whoever has tried to coerce a solid-liquid system (as I did) knows that he has a task on his hands; and whoever tries to diminish bulk 20 or 30 per cent. (which I didn't do) is destined to fall very short of his hopes. I argued, therefore, that the solidification of water in glass, under the exceptional conditions stated could hardly take place without the evolution of heat such as accompanies any solidification of the liquid. All efforts to prove the inference directly miscarried; but in case of a reaction which proceeds very gradually, in small compass and under high pressure, failure is almost a foregone conclusion. Nature, as Elihu Thomson truly states, in her ideal laboratory can garner the heat of a slow process, while such heat slips irrecoverably through our fingers in the workshop. At this point then my argument is based not on direct but on circumstantial evidence, and if I were the reader, and not the writer, I would merely grant a fused glass at a temperature presumably somewhat higher than the melting point.

To me the picture obtainable from the bearing of these experiments on vulcanism is more attractive than any other with which I happen to be acquainted, even if I have to chaffer uncomfortably for the excess of heat above mere fusion which seems to be present, as if my glass had gnawed its way convectively into the higher temperatures of deeper isotherms. The idea[3] here is important: it is probable that the water in a magma at 200° will diffuse into a magma at 300° (and higher in turn), across the surface of contact. The region of fusion is, therefore, essentially *sinking* in character in its avidity for magmas at

[2] *American Journ*, XLVI., p. 110, 1891; VII., p. 1, 1899; IX., p. 161, 1900. *Phil. Mag.*, XLVII., p. 104, 461, 1899.

[3] Inferred because the rate of solution increases rapidly as temperature rises. Moreover the higher temperatures of deeper isotherms are being continually brought from lower to higher levels by convection, as solution proceeds.

higher temperatures. If the supply of water holds out above, the fused region will enlarge downward and laterally until, with excessive size, the rigidity of its confines breaks down.

To keep water liquid at 200° C. it is merely necessary to tap the ocean at a level greater than 500 feet below the surface, while a depth of five miles of water may be available. The 200° isotherm may also be put at a distance of about five miles below the solid surface, but it is correspondingly lifted up on the shores of the ocean. Near the ocean, therefore, this earth level is potentially fused, if by whatever catastrophe the ocean penetrates as far as the 200° isotherm, barring the 3,000 atmospheres of pressure which one may ascribe to the given depth of the isotherm below the surface. In view of the rigidity of rock, such pressures are not yet irresistible, when burdening the solid framework of a region not too large. The effective pressures are smaller. Fusion will depend upon the character of the rock magma found in place; it will be rapid if basic, slow if acid, but will in every case constitute a local source of heat, since as in Thomson's case, the region of reaction is nicely jacketed in a way to guarantee the utmost amount of mischief. More than this; water-glass becomes saturated subject to temperature and pressure, after which the heat reaction ceases, and the chances for vulcanism become extinct. Furthermore, there is a chance for periods. Finally one would expect the region of volcanic activity to correspond in depth with the depth of the ocean; and again to be on the margin of the ocean without being necessarily absent in the interior of continents. Could anything be more cleverly dovetailed? What if the heathen rage and say 'qualitative' or 'inadequate'; what if throughout all the turmoil of the Pelée eruptions, not a soul has thought it worth while to quote my results. I am now doing this myself.

But Elihu Thomson will have none of it. 'No water would enter a hot stratum unless forced in by pressure in excess of that which the steam would acquire upon its generation,' etc. Unfortunately we have to do with much more than a mechanical phenomenon. The chief pressures in question are capillary and osmotic pressures. Steam will pass through porous rock against very considerable pressures.[4] I remember that I once had an occasion to pass a very fine spray of air through water. Nothing seemed simpler: I tried to force the air through a submerged cup of unglazed porcelain. But it would not work! A little consideration showed me afterwards that it takes ten atmospheres to do that, and the wretched old trap blew up before this pressure was reached. Through dry porcelain the air escapes jauntily enough, but it will not do so if the pores are stoppered with water. One may estimate in the same way that pores of molecular dimensions, as in case of osmotic phenomena, and diffusion would call for many thousands of atmospheres if water is to be forced through, so that the pump which feeds the vulcanic boiler to use Thomson's image, is not a cast-iron contrivance. But apart from this, having once fused my glass I am at liberty to putty up every fissure that may interfere with my business. I am quite unwilling to leave Elihu Thomson a single crack to puff away my steam, unless it be the cataclysmal break-up by which my glass, pumiced or not, or any of its ingredients, water and mud, are finally ejected. Here I can accommodate him periodically.

Major C. E. Dutton's recent article[5] breaks off entirely with his old-fashioned comrades and looks at volcanoes from a new point of view. I always read Dutton at arm's length when I differ from him, lest the trenchancy of his style rob me of the charm of my own convictions. And the case here in question is even more disquieting. Whoever invokes radio-activity silences most of us; for if the incantation be potent enough, there is very little that the wily electron can not do. But in this instance, not a few have been in quest

[4] 'I have not the data at hand, but they will be found, if I remember, in Oscar Peschel's 'Erdkunde.'

[5] 'Volcanoes and Radioactivity,' *Nat. Academy*, April 17, 1906.

of radio-active fortunes supposedly stored in the bowels of the earth. In one of the last annalen, August Becker,[1] studying the lavas of Vesuvius in the Lenard's laboratory, detects no unusual radioactivity in the magmas from deep sources, while Lord Kelvin has lately girded his gravitational vestments anew, and is thundering in the *Times* for a return to the simple life, free from radio-active refinements.

We may summarize, therefore, that in each case specific evidence for the adequate occurrence or the localizations of volcanic heat is wanting. Apart from this the manufacture of volcanoes is as easy as an after-dinner discussion. Suppose, for instance, we all got to work conjointly; let me supply the broth, as I trust, thick and hot, while Elihu Thomson kneads in the energy and Major Dutton bombards the whole with α particles. Could anything withstand us? True there has been stuff predicted

> "Impenetrable, impaled with circling fire,
> Yet unconsumed,"

but this need not be mentioned (at least not in the summer), as it is gravely questioned whether it will fit into the periodic law, and it does not concern us if we are good.

CARL BARUS.

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THE RIGIDITY OF THE EARTH.

TO THE EDITOR OF SCIENCE: In his discussions of the interior condition of the earth (SCIENCE, September 7, 1906, and elsewhere), Professor T. J. J. See advances the proposition that the interior matter of the earth is at the same time fluid and highly rigid. Taking the words in their accepted meaning this is a contradiction in terms. If the intended meaning is that deep-seated material is kept solid only by pressure, it is of course no new hypothesis. The experimental evidence for rigidity, which has been adduced by Kelvin, Darwin and others, concerns, however, only the actual present rigidity of the earth, and has no bearing upon the question whether this is or is not due to pressure.

Professor See's own supposed deduction of the earth's rigidity (*Astronomische Nachrichten,* 4104) apparently rests upon a complete misunderstanding of the meaning of modulus of rigidity. He quotes from Kelvin a definition of this modulus stated in a somewhat unusual form which seems to have misled Professor See as to its meaning, although this is made quite clear by the context. The definition quoted is from the article on Elasticity, Encyclopedia Britannica, Vol. VII., p. 805, and is as follows:

> **The modulus of rigidity of an isotropic substance is the amount of normal traction or pressure per unit area, divided by twice the amount of elongation in the direction of the traction or of contraction in the direction of the pressure when a piece of the substance is subjected to a stress producing uniform distortion.**

The context shows that this definition refers to a body subjected to a traction in one direction, an equal pressure in a rectangular direction, and zero stress in the third rectangular direction. The accompanying strain is the 'uniform distortion' referred to in the definition. With this understanding the definition is exactly equivalent to the more common definition which immediately precedes the one quoted, and which reads as follows:

> **The 'modulus of rigidity' of an isotropic solid is the amount of tangential stress divided by the deformation it produces.**

For a fluid the value of the modulus of rigidity as thus defined is necessarily zero. Professor See, however, apparently infers from the definition quoted by him that the modulus of rigidity of any body, solid or fluid, is equal to the normal pressure to which it happens to be subjected. At all events this is the basis of the method by which he computes the rigidity of the earth and of other planets. Assuming Laplace's law of density and the resulting distribution of interior pressure, he computes the average pressure throughout the earth and calls this the mean value of the modulus of rigidity for the earth. Of course, Kelvin's definition admits of no such interpretation.

L. M. HOSKINS.

PALO ALTO, CAL.,
September 13, 1906.

[1] *Annalen der Physik,* XX., p. 634, 1906.

THE INTERIOR OF THE EARTH.

To the Editor of Science: Professor Thomson's recent article on the cause for volcanic action, which begins with a reference to the theory of a liquid interior of the earth as exploded, taken in connection with a recent paper by my friend, Dr. Daly, has set me thinking as to what we mean by speaking of the interior of the earth as either solid or fluid. That if fluid it is in general highly viscous is certain; that if solid it is also often subject to stresses above its crushing strength, under which it flows like punched steel, all will agree. But are we clear as to where we are to draw the line between viscous fluid and solid? We have, on the one hand, substances, which, like the splinters of albite described by Day, are so viscous as to retain their form even when heated so that they have lost their crystalline structure and then become optically homogeneous, and we have, on the other hand, experiments like those of Adams on the flow of rock solids. I do not think we can come to any clear idea or definition without emphasizing the relation of time. Molasses candy and tar appear ordinarily as solids and crack and break as such, yet given time enough they flow, and are properly classed as viscous fluids. In geologic problems we have large quantities and long times at disposal. The argument for the solidity of the earth from its resistance to the pull of the sun and moon proves that it is highly rigid, but not at all that it may not be a viscous fluid, because the time in which the stresses are applied is relatively brief.

The scientific distinction between solid and fluid may be derived from the common idea of a solid as that which has a form of its own, while the fluid takes the form of the containing vessel, bounded by a level surface on top. It is obvious that we must give it time to take the form in question. A very viscous fluid may take a very great time, yet it will ultimately assume the same form as the other fluid. Whence we may base an ideal definition and say that anything to be classed as fluid will, in sufficient time, come to the same state of equilibrium as water, *and is not able to rest in a state of strain, but yields to a stress however small or slowly applied.* Whereas a solid, such as a crystal of quartz, might be under a light stress producing a slight strain for infinite time without any tendency to permanent distortion.

For geological purposes we do not need to deal with quite infinite time. While stresses such as those of the tides and volcanic earthquake shocks are far too quickly applied to discriminate between viscous fluids and solids, the slow erosion of a continent by the fraction of a thousandth of a foot a year, the slow attendant deposition of sediment on the ocean floor and the slow escape of energy from the interior of the earth are examples of forces so slowly applied that if there is any degree of real fluidity worth mentioning in any layer of the earth, there could be no accumulation of such stresses in it, but they would be yielded to as fast as formed.

According to a geological theory known as that of isostasy, there is something like this continuous yielding in the case of erosion and deposition, the continents being uplifted as they are eroded, while the ocean shores are depressed, so that continents float above the general earth level because they are lighter, like icebergs in water, and not because they are supported by stresses in the earth beneath. In the same way the earth is supposed to have been depressed beneath the icecap and to have risen again, tilting the shore lines of the Great Lakes, when the ice melted away. If this theory is strictly true it would seem to me that we must assume a viscous fluid substratum. But is this process absolutely continuous, or only 'steady by jerks,' the yielding occurring only after a certain degree of strain is accumulated? Upon the possibility of accumulation to some extent of very slow strain should depend the answer as to whether there is a viscous fluid or plastic solid substratum of the earth. As President McNair has suggested to me, there is an experiment now being unwillingly tried on a gigantic scale which might throw light on this. The Colorado River is about to cover some 2,000 square miles in the next 30 or 40 years with

water over 200 feet deep. Will this gradually applied extra load produce a gradual depression? This might almost seem a crucial test, and it would seem as though a few well-placed and well-determined bench marks on projecting hills, or possibly triangulation tripods, in the area to be submerged would answer the question. And it is the hope of arousing interest and causing the necessary measurements to be made that has spurred me to write this note. ALFRED C. LANE.

THE GEOGRAPHICAL DISTRIBUTION OF STUDENTS.

IN the article on 'The Geographical Distribution of the Student Body at a number of Eastern and Western Universities and Eastern Colleges,' which appeared in the issue of SCIENCE for August 10, 1906, I neglected to call attention to the fact that the showing of a number of the state universities is somewhat misleading, for the reason that many students from outside the state in which the university is located endeavor to establish a state residence, in order to escape the tuition charged to outsiders. This is true particularly with reference to the University of California, on account of the isolation and the large size of the state. Families of students from outside often establish a temporary residence in Berkeley, and a similar state of affairs no doubt exists with reference to the University of Michigan and other state universities. At California not over one quarter of the students coming to the university from outside the state and from foreign countries are so registered. RUDOLF TOMBO, JR.
Registrar.

SPECIAL ARTICLES.

THE PRESERVATION OF SURFACE CONDENSER TUBES IN PLANTS USING SALT OR CONTAMINATED WATER CIRCULATION.[1]

THE prevention of electrolytic corrosion of condenser parts where they are subject to contact with condensing water that contains electrolytic properties has been a serious problem with condenser engineers at sea as well as on land, where the condensing water contains salts in solution. This action is especially destructive where the cooling water is contaminated further with chemicals or with sewage.

In the great steam plants of New York city where the water bills extend into thousands of dollars per annum, in fact, are approximately one tenth of the fuel bills, this is an important condition bearing upon the cost of the hourly power unit, but the attempt to use surface condensers in the past for the purpose of saving this waste has not been accompanied with any degree of success. The highest economy demands such precautions as shall leave the hot-well water coming from the condensers in a proper condition for feeding the boilers.

The waste incident to the inability to save this water in stationary generating plants has caused the construction of surface condensing apparatus at such plants as that of the Brooklyn Edison Company at Bayridge, and of the Metropolitan Street Railway Company at 96th Street, New York City.

At the time the design of the Long Island City Power House of the Pennsylvania Railroad was undertaken, it became evident that true economy in the operation of a plant which would have under ordinary circumstances an annual water bill of about $100,000, when the plant has been fully put into service, justified an attempt to save the water from the hot well for replenishing the boilers. This seemed to demand a thorough investigation of the matter of condenser protection where the circulation cooling water was an electrolyte as it was in this case.

The site where this plant was to be constructed was at Long Island City near the harbor front, and the plant was designed to contain, when fully constructed, fourteen 5,500 K.W. generating units. With such an equipment and with an ordinary loading, the amount of boiler feed water required per annum would cost in the neighborhood of $100,000.

In the investigation of possible methods for

[1] Read at the Ithaca meeting of the American Association for the Advancement of Science, June 29, 1906, before Section D—Mechanical Science Engineering.

preventing the rapid destruction of condenser tubes and parts, an effort was made to find out if the condenser engineers of the country did not have suitable information as to the nature of the action tending to destroy the thin tubes and preventing tightness in the condenser, or had not made trials to indicate effective methods of protection. The most competent opinion that we could get was that if we could adjust the difference of potential due to stray ground traction or other currents to a value of less than three volts, we should have no difficulties; that the trouble was all due to stray ground currents from electric railways and that stray currents from lighting plants had little or nothing to do with the corrosion. They further stated that all that was necessary was to insulate from the possible inflow into the condenser of stray currents from traction operations. It had been found that these currents were already destroying the city water pipes of the vicinity along which they were traveling and to which connection would have to be made.

With a view to discovering a method of protection, we carefully investigated this statement based on the action of a device at the Brooklyn Edison Company's Bayridge Plant caring for this condition, and found it had been an abject failure, ending in the abandonment of surface condensers, and the installation of elevated jet condensers at considerable expense, and consequent wasting of the water of condensation. Numerous other instances, more or less efficiently handled, were found. Some of the condensers in other steam plants were so designed and the connections so made that it was absolutely essential to permit the sea-water from the main spaces to pass into the steam space of the condensers by the actual removal of tubes, thereby preventing the re-use of feed water from the hot wells, even if they had been tight otherwise.

It became evident at once that there was really nothing accurately known about the destructive actions that were taking place in condensers and that a systematic study of the situation for Long Island City was demanded before we should decide on the type of condenser and the wisdom of trying to use hot-well water in the boilers.

To that end, we measured the stray currents and we found that the voltage of the railroad rails in the terminal freight yard of the Long Island Railroad at points between the power house and the river was at times as much as nine volts above the potential of the river; that this caused a flow of current to the harbor and a destruction of water pipes and other things in the railroad yards, and that anything that was done would have to be not only able to compensate for this nine volts but must further provide for the control to fit modifications thereof in such a way as to prevent reverse current actions and corrosion of other things. In other words, with the peak of the load on the Brooklyn Rapid Transit, the voltage would go to nine volts; and as the load sagged off it would decrease, until it was only a volt or two. Therefore, whatever was put in must be thoroughly controllable from time to time by switchboard appliances.

In order to properly study the real conditions a number of large glass jars were provided and various combinations of metals were immersed in samples of water taken from the river at Long Island City, of sea water from off Far Rockaway, as well as of pure water.

It became evident that the effect of samples of water from the East River was much more violent than that of ordinary sea water. It was further observed that there was a local action going on which was galvanic, and that the amount of stray currents had something to do with the polarization of the surfaces in galvanic action, making the galvanic action exceedingly violent and destroying thin copper tubes at a very rapid rate. There would be punctures of these tubes in four or five days' time which would be fatal to the commercial requirements, producing a very serious repair item in order to maintain the condensers sufficiently to permit their being used to return the reclaimed or hot-well water to the boilers.

In other words, it would render it impossible to keep them in a suitable condition, as the

water would be contaminated with salt-water leakage.

It soon became evident by observation of the several combinations in these cells, that there was a violent local action between the zinc and the copper of the brass tubes which were in contact with the electrolyte, and that this increased in the reaction as it progressed in stagnant conditions.

It then became necessary to find a method more comprehensive than the proposed simple counter-electromotive force for the neutralization of the traction companies' stray currents. Further experiments with plates immersed in the cooling water samples showed that by interposing a counter electromotive force against the galvanic couple which should exceed in pressure the voltage of the galvanic couple, the actions of the electrolytic corrosion ceased. The difference in potential between the zinc and the copper for the Long Island City harbor water was found to be 0.4 of a volt. Zinc and copper were selected in these experiments because the condenser tubes were to be made of 60 per cent. copper and 40 per cent. zinc. It became evident that when unconnected, or electrically separated, plates were placed in this electrolyte, if they were of composite construction and had sharp projections into the fluid, raised by cutting and prying up with a knife, they would have these projections promptly destroyed, and that if an electric battery having a pressure exceeding that of the couple in the East River water was caused to act to produce a counter current, and having a pressure exceeding that of the galvanic couple, the capacity of this electrolyte to drive off atoms of the mechanically combined metals in the alloys used was overcome and corrosion was arrested.

It, therefore, became desirable to not only carefully provide the balancing quantity of current to equal the stray traction currents arising from the ground returns of railway and other service, but to add to this the necessary voltage through a cathode placed in the circulating water in such a way as to bring to bear electrolytic action which would prevent the galvanic action due to this current coming into contact with alloys of mechanically combined metals such as the brass tubes.

It became evident that the influence of various foreign substances in the East River water made the galvanic couple as between an atom of zinc and an atom of copper greater than for open sea water, and it was found to be at times as high as 0.42 of a volt. With this known it was planned to put a pressure of 0.6 of a volt on the anode in order to overcome this action and prevent the separation of the zinc molecule from the surfaces and the consequent breaking down of the tubes.

In order to accomplish these two things, it was first necessary to so install the condensers as to prevent undue amounts of stray currents flowing through them, thus tending to reduce the amount of power required to prevent injurious action of these currents and otherwise to neutralize them. This was done by insulating the joints in the piping and from ground connections and even lining the large water connections with glass melted on to the surface.

To furnish electromotive force, a 3-K.W. motor generator was provided. It was of the form used for electroplating. By means of a system of wiring, switchboard apparatus and appliances, together with ammeters and voltmeters for measuring quantities and pressures, and a connection to an outlying anode in the condensing supply intake at its harbor end, this generator was planned to provide current to neutralize the stray currents in the condenser structure to any extent that they had passed the insulated joints in the supports and connections, as well as through the columns of water in the pipe connections, and then to adjust the additional voltage needed to counteract and prevent the galvanic action.

This led to much discussion as to methods and the reasons why the corrosion was prevented; and it became necessary, in order to get at the facts in the matter, to review the history of electrolytic conduction. A reference to Faraday's Laws and to the results of the experiments of Helmholtz and Clausius, explained the nature of this electrolytic con-

duction and the reasons for its action. The best explanation is summed up in Professor Oliver J. Lodge's 'Modern Views of Electricity,' chapter four on 'Electrolytic Conduction,' as follows:

1. Electrolytic conduction is invariably accompanied by chemical decomposition, and in fact only occurs by means of it.

2. The electricity does not go through, but with the atoms of matter, which travel along and convey their charges something after the manner of pith balls.

3. The electric charge belonging to each atom of matter is a simple multiple of a definite quantity of electricity, which quantity is an absolute constant quite independent of the nature of the particular substance to which the atoms belong.

4. Positive electricity is conveyed through a liquid by something equivalent to a procession of the electro-positive atoms of the compound, in the direction of the current; and at the same time, negative electricity is conveyed in the opposite direction by a similar procession of the electro-negative atoms.

5. On any atom reaching an electrode, it may be forced to get rid of its electric charge, and, combining with others of the same kind, escapes in a free state; in which case visible decomposition results. Or it may find something else handy with which to combine, say on the electrode or in the solution; and in that case the decomposition, though real, is masked, and not apparent.

6. But, on the other hand, the atom may cling to its electric charge with such tenacity as to stop the current; the opposition force exerted by these atoms upon the current being called polarization.

7. No such opposition force, or tendency to spring back, is experienced in the interior of a mass of fluid; it occurs only at the electrodes.

The first three of these statements constitute a summary of Faraday's Laws of Electrolysis.

The claim was made, immediately upon the application of this apparatus, that the electricity coming from the anode, which in this installation was of cast iron but which ordinarily would be of carbon, would short-circuit on to the very ends of the tubes instead of passing through the tubes to the several points which might be exposed to galvanic action. This, however, does not seem to be the case, and in fact is entirely accounted for by the following remarks from the above-mentioned work on 'Modern Views of Electricity':

But it may be asked, 'If the atoms in each molecule cling together by their electrostatic attractions, and, as there are an enormous number of atoms between the two electrodes, how comes it that a feeble electromotive force can pull them apart and effect decomposition; moreover, how can the electromotive force needed to effect decomposition help varying directly with the thickness of the fluid between the plates?' It does not depend upon anything of the kind; the length of the liquid between the electrodes is absolutely immaterial. This proves that throughout the main thickness of the liquid no atoms are torn asunder at all. Probably, they frequently change partners, one pair of atoms not always remaining united but occasionally getting separated and recombined with other individuals. During these interchanges there must be moments of semi-freedom during which the atoms are amenable to the slightest directive tendency, and it is probably these moments that the applied electromotive force makes use of.

The reality of such a state of continual interchange between molecules has been forced upon chemists by the facts of double decomposition, such facts as the interchange of atoms between strongly combined salts where their solutions are mixed so as to form very much weaker compounds; the proof that such compounds are formed being very clear in the case when they happen to be insoluble.

The fact that the most infinitesimal force is sufficient to effect its due quota of decomposition has been proved most clearly and decisively by the experiments of Helmholtz.

Moreover, electrolytic conduction is perceived to be scarcely of the nature of true conduction: the electricity does not slip through or among the molecules; it goes with them. The constituents of each molecule are free of each other, and while one set of atoms conveys positive electricity, the other set carries negative electricity in the opposite direction; and so it is by a procession of free atoms that the current is transmitted. The process is of the nature of convection: the atoms act as carriers. Free locomotion of charged atoms is essential to electrolysis.

Professor Lodge also says:

For any element, whatever, the number of atoms liberated in any time is equal to the number of

atoms of hydrogen liberated in the same time divided by the 'valency' of the element as compared with hydrogen. This law was discovered by Faraday; and appears to be precisely true: and inasmuch as the relative weight of every element is known with fair accuracy, it is easy to calculate what weight of substance any given current will deposit or set free in an hour, if we once determine it experimentally for any one substance.

By this means, we succeeded in properly adapting the sizes of the generating and other apparatus. All connections were made in a manner to insure a uniform voltage of the various parts of the condenser to prevent local action, each connection being so made and provided with such measuring instruments as to insure ready adjustment to effect this. The apparatus was designed in accordance with the above statements. Its operation has extended over a period of fourteen months, and with the exception of about ten tubes which have become pitted, the results have been satisfactory.

When the condenser was planned, the condenser manufacturer was instructed to slope the tubes down one inch in the direction of flow; but when he did so, it was forgotten that the middle inclination, if parallel to the first and third passes, would then be up-hill for the circulating water, and that when the condenser was shut down all the water would drain out of this middle section except that in the bottom tubes. These bottom tubes it has been found have become somewhat corroded, although not seriously.

The cause for this result having now been found, its prevention has been effected by perforating the diaphragm in the condenser head to permit prompt drainage of these tubes when the condenser is taken out of active operation.

The efficiency of the apparatus amply justifies the expense of its installation, while its operation is not expensive and the plant here described will now be followed by other protecting plants of the same character.

W. W. CHURCHILL.

QUOTATIONS.

THE NEXT INTERNATIONAL TUBERCULOSIS CONGRESS.

THE International Tuberculosis Congress takes place at intervals of three years, and the latest was held in Paris last autumn. The next, therefore, is due in 1908, and Washington has been selected as the place of meeting. It seems a far cry from now to the autumn of the year after next; but the American National Association for the Study and Prevention of Tuberculosis, which has general charge of the arrangements, evidently intends that this meeting shall be notable among congresses, and with laudable forethought has already got its plans something more than mapped out. As an initial step it set itself the task of collecting a sum of $100,000 towards the expenses, but resolved to get this amount in a fashion quite impossible in any country on this side of the Atlantic. In other words, the minimum subscription was placed not at five shillings but at five thousand dollars, in the belief that there would be no difficulty in finding at least twenty citizens of the United States ready for such an object to put their hands into their pockets to the tune of £1,000 each. Nor does it appear likely that these rose-colored expectations will be falsified, for about half the sum desired is already in hand. There is a double object, however, in this early collection of the sinews of war. A sum of $100,000 lying at interest at American rates for a couple of years will enable another scheme to be fulfilled. This is to award prizes of considerable value to the authors of the best papers sent to the congress on certain selected subjects, such as municipal control, bacteriological treatment and sanatoriums, as also to anti-tuberculosis societies which can show the largest increase in membership since the congress of 1905, and to the city, wherever situated, which can claim the greatest improvement in its phthisis mortality rates during a corresponding period. The exact subjects have not yet been finally determined, but it is understood that an announcement of them is to be expected before very long. A further novel suggestion which

seems likely to be adopted is that by way of making it worth while for those in Europe to cross the water, and also of affording a certain latitude, the congress shall officially last three weeks. Only the middle week, however, is to be devoted to scientific meetings and discussions, it being proposed that the first week shall be given up by visitors to exploring some of the other great cities of the United States north of Washington, in which official arrangements will be made for their reception, and the third week to similar official visits to cities southwards. The idea is that there may be many who could reach Washington some little time before the scientific proceedings commence, but would have to leave immediately on their termination, while others could spare plenty of time afterwards, but none before, and that by placing the discussions in the middle week America will be able to show public hospitality to visitors of either class.—*The British Medical Journal.*

CURRENT NOTES ON METEOROLOGY.

CLIMATE AND ALTITUDE IN AFRICA.

The tempering effect of altitude, even within the tropics, is well known. The vice-governor of the Congo Free State, in a recent description of a journey over the Uganda Railroad (*Mouvement Géographique,* No. 16, 1906), brings out this point in his notes on Nairobi, an important town on the line west of Mombasa, about half-way between the Indian Ocean and Victoria Nyanza, at an elevation of 5,450 feet. Here it is possible to raise several varieties of European fruits, vegetables and cereals; the European population is increasing, and many of the white settlers have brought their families. It is further stated that they have no desire to return to their native land. If this be true, it marks a radical departure from the usual rule for white settlers in the tropics, but it is doubtless an exaggerated statement, or has its origin in the fact that most of the Europeans have been at Nairobi but a short time and have not yet attempted to bring up their children there.

Concerning German East Africa, the government of that district has recently issued a circular for the use of white colonists who intend to settle in the Kilimanjo province. The province consists chiefly of grassy steppe, and the industries must be general agriculture and stock-raising, in the main. The altitude mitigates the heat, although the region is only about 200 miles south of the equator.

Major Gibbons (*Geogr. Journ.,* March) has studied the western part of the high plateau region of British East Africa with a view to ascertaining its adaptability for European settlement. Most of the plateau is 6,000 feet above sea-level. Major Gibbons believes that this, as well as other higher altitudes in this part of Africa, will be classed as healthy countries, and that they will have considerable agricultural development.

MONTHLY WEATHER REVIEW.

Recent numbers of the *Monthly Weather Review,* Vol. XXXIV., 1906, have contained the following notes and articles of general interest: 'The Relation between Storm Movement and Pressure Distribution,' by E. H. Bowie; 'Climatology of Haiti in the Eighteenth Century,' by C. F. Talman; 'Vertical Air Currents,' by F. W. Proctor, who notes that he has several times had toy kites lifted by vertical currents during summer anticyclonic weather, thus showing the presence of small irregular rising bodies of air. A case of 'Snow formed by Mixture of Warm and Cold Air' is described by R. W. Gray, observer at Atlantic City, N. J. On February 6 last snow fell during a part of the day when the sky was perfectly clear. At times the flurries were quite heavy. Condensation seemed to occur at not more than 75 to 100 feet above ground, and in a region of mixture of cold northwest land wind with a warmer, damp ocean wind. Consul-General Skinner, at Marseilles, describes the new method of frost protection in use in the vine-growing regions. A newly-invented preparation, known as the 'Fumigène Mortier,' packed in boxes containing about nine pounds of black powder, and costing 1.50 franc each, is much used in producing thick smoke, which has proved very effective in

checking radiation and thus decreasing the danger of frost. Professor Cleveland Abbe contributes some further notes on the life and work of Espy. In connection with a letter from a correspondent in Curaçao, who attributes to deforestation in that island certain electrical effects which now produce less rain than formerly, Professor Abbe ('Drought and Atmospheric Electricity') takes occasion to point out what is known regarding the connection between rain and electricity. In a series of observations on 'The Zodiacal Light,' Dr. Maxwell Hall reaches conclusions which would relegate this phenomenon to the department of astrophysics, the influence of the atmosphere being only to render obscure the fainter details. In a note on 'Cloud Banners,' reference is made to the report that heavy columns of smoke or steam were ascending from the peak of Mount Rainier on March 6 last. Public attention was attracted by the phenomenon, and it was eagerly watched. In reality, it was a cloud banner of the ordinary type, developed in a warm southerly wind. A similar appearance, in December, 1904, led to the sending of an expedition up the mountain by a Seattle newspaper. A review of a recent paper by Brückner on the influence of the oceans on precipitation over the continents brings out the fact that if the figures and underlying assumptions are taken as accurate, it appears that were the influence of the oceans eliminated, the continents would still receive four fifths of their present precipitation.

CENTRAL LOW PRESSURE IN A TORNADO.

A FEW years ago there was no barograph record from the center or from near the center of a tornado. Almost every year now some tornado in the United States passes near enough to a Weather Bureau station to leave some record of its existence on the curve traced by the self-recording barometer, yet the number of these records is not yet so large that new ones are uninteresting or not worth noting. The tornado at Meridian, Miss., March 2 last, whose passage caused a considerable loss of property and resulted in the death of 23 persons, was within 250 yards of the local office of the Weather Bureau. The barograph pen dipped .16 inch, and recovered almost immediately, making a straight line down from the main part of its curve. This is the usual form of tornado pressure curve. A facsimile of the original tracing may be found in the *Monthly Weather Review,* 1906, p. 118.

NOTES.

'SOME Meteorological Results of the Scottish National Antarctic Expedition,' by R. C. Mossman, appear in the *Scottish Geographical Magazine,* Vol. 22, 1906, pp. 252–272. This is a more complete discussion than has hitherto been published, and is illustrated by means of curves and wind roses. The most important results of the *Scotia* expedition have already been noted in SCIENCE.

THE rainfall of a region little known meteorologically, German Southwest Africa, is discussed by T. Klengel in *Das Wetter,* 1906, beginning with the April number and extending through July.

THE optical effects resulting from the dust thrown out in the recent eruption of Vesuvius are briefly discussed in the July number of *Das Wetter.*

R. DEC. WARD.

BOTANICAL NOTES.

A NEW FLORA OF COLORADO.

ABOUT thirty years ago Professors Porter and Coulter prepared a very useful 'Synopsis of the Flora of Colorado,' and ten years later this was expanded by the junior author into his well-known and widely used 'Manual of the Botany of the Rocky Mountain Region.' In the two decades since the appearance of the latter so much has been done in the collection and closer study of the plants of the Rocky Mountain region that these old books no longer represent the present state of our knowledge of the species and their distribution. Dr. Rydberg's 'Catalogue of the Flora of Montana and the Yellowstone National Park' (1900) gave some idea of what additions and changes would have to be made in

a comprehensive treatment to-day of the plants of the region. Several years ago the officers of the Agricultural Experiment Station of Colorado felt the need of having the growing botanical collections of the station determined more accurately than was then possible with the available manuals and other publications, and appealed to the director of the New York Botanical Garden for such help as he could afford them. The ultimate result of this appeal is a well-printed octavo volume of more than 450 pages, entitled the 'Flora of Colorado,' and published as Bulletin 100 of the Colorado Experiment Station. It is the work of Dr. P. A. Rydberg, whose acquaintance with the Colorado flora is based upon much actual study and field work in different parts of the state, in addition to the rich collections in the herbarium of the New York Botanical Garden. It has been known for some time that he has had in preparation a manual of the botany of the whole Rocky Mountain region, and the present volume is thus a sort of prodrome of that work.

The plan of the book is similar to that of the very useful 'Flora of Pennsylvania,' prepared a few years ago by Dr. Porter. By convenient keys in the beginning of the book the orders are sufficiently characterized for recognition; then on the designated page of the volume by another key the families are briefly characterized; and so in like manner under each family is a key to the genera, and under each genus, a key to the species. Finally after the specific key each species is given a separate paragraph, including the authority, habitat, general distribution in North America, particular distribution in Colorado, altitude, and now and then a synonym. It is thus a synoptical manual, and has the merit of maintaining the identity of order, family, genus and species, a matter of no small importance to the beginner who wishes to know something more than the mere names of his plants. A failure to maintain such distinctions is a grave fault of many of the local manuals accompanying botanical text-books. Dr. Rydberg's book will no doubt at once become the handbook for the student and collector in Colorado, for which it is admirably adapted.

From the preface we learn that it contains 'over 700 genera, and 2,900 species' of fernworts and flowering plants, and that 19½ per cent. of these are composites; 9 per cent. grasses (*Poaceae*); 6½ per cent. *Fabaceae;* 5 per cent. *Brassicaceae;* 3½ per cent. sedges, etc.

The nomenclature is modern, and the treatment of genera and species quite radical, yet the author has not published any new genera or species in the book, thus setting a good example, which it is to be hoped will be followed by other botanists who prepare similar floras. It is a good piece of work, and the officers of the experiment station are to be congratulated upon their liberality and foresight in providing for its publication.

THE NORTH AMERICAN CHAREAE.

Twenty-seven years ago Dr. B. D. Halsted published in the *Proceedings* of the Boston Society of Natural History a twenty-page paper entitled the 'Classification and Description of the American Species of Characeae,' including characterizations of all of the species then known in North America, viz., of *Nitella* 8 species, *Tolypella* 1, and *Chara* 9 species and 6 varieties. Three years later Braun's 'Fragmente' increased these numbers to *Nitella* 21 species, *Tolypella* 3, and *Chara* 15, besides many varieties and 'forms.' Now we have a paper, 'The Chareae of North America,' published by Dr. Charles B. Robinson in the *Bulletin* of the New York Botanical Garden, which shows what progress has been made in the last quarter of a century in the study of these interesting plants. As indicated in the title this paper is limited to the *Chareae,* a subfamily represented in this country by the genus *Chara* only, and yet the author finds more species (50) than were recorded in all our genera by previous students. Of these species fifteen are here described for the first time, while ten varieties are raised to specific rank. Of the new species two each come from New York, New Jersey, Canada, Michigan, Florida and Mexico, while Kansas, New Mexico and Illinois add one each.

The paper, which covers 64 pages, includes a ten-page structural and historical introduction, followed by a key to the species of *Chara*. Following the key are full descriptions of all of the species, with the type locality, distribution, illustrations and exsiccatae for each species. Suggestive critical notes are appended in many cases, adding much to the value of this important contribution to our knowledge of this interesting group of plants.

A MOSS BOOK.

SOME weeks ago Part III. of Dr. Grout's 'Mosses with Hand-lens and Microscope' came to hand, continuing the work from page 167 to 246. In this part we have the completion of the family *Tortulaceae*, and the treatment in succession of *Encalyptaceae, Orthotrichaceae, Schistostegaceae, Splanchnaceae, Funariaceae, Meeseaceae, Timmiaceae, Aulocomniaceae, Bartramiaceae, Bryaceae* and *Leskeaceae*. The two families to which the most space is given are *Orthotrichaceae* and *Bryaceae*, which together take up more than half of the pages of this part. The illustrations and text maintain the high standard set by the author in the two preceding parts. The statement is made that two more parts will complete this important and very useful work.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

CENTRAL BUILDING OF IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

ON June 8, 1906, the new central building of the Iowa State College of Agriculture and Mechanic Arts was dedicated. Hon. W. J. Dixon, in speaking of the construction of the building, said:

> The building is 216 feet long by 112 feet in depth. Floor area 98,000 square feet. The building contains 1,892,738 cubic feet of materials. The base is of Georgia granite and the outer walls of Bedford stone. The roof is tile set in concrete. Construction is fire-proof throughout. The plumbing, heating and lighting is of the most approved modern systems. The cost of the completed building is $375,000.
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> The architects were Proudfoot & Bird, of Des Moines; the builder was Henry W. Schleuter, and the superintendent of construction was Dean Anson Marston. The furniture cost $52,000.

The commencement address was made by Dr. F. W. Gunsaulus, of Chicago. The following number of degrees were conferred: B.S.A., 34; D.V.M., 4; B.M.E., 19; B.C.E., 27; B.S. in E.E., 21; B.S. in Min.E., 8; B.S., 14, three men and eleven women; M.S.A., 6; C.E., 1; M.S., 2; B.D.S., 1. One honorary degree of M.Ph.

At a meeting of the board of trustees on June 1, R. Earle Buchanan was made assistant professor of general bacteriology and Estelle D. Fogel was made instructor in botany.

The following departments have rooms in the new central building: English, history, mathematics, civics, economic science, modern languages, elocution and oratory. There are also general offices for the board and the secretary, the purchasing committee, the president and faculty, and a reception room, treasurer's office, and the rooms of the department of botany. The department of botany occupies most of the upper floor and the attic story.

L. H. PAMMEL.

SIR WILLIAM PERKIN AND THE AMERICAN JUBILEE OF THE COAL TAR INDUSTRY.

WE have already noted the British celebration in commemoration of the fiftieth anniversary of the discovery of the dye-stuff mauve by Sir William Perkin. American chemists decided to celebrate the foundation of the coal tar industry independently, and Sir William Perkin and Lady Perkin left Liverpool on the *Umbria*, on September 22, to be present at a banquet which will be given at Delmonico's, on October 6.

The American committee submitted to a public meeting, held May 28, 1906, the following program: (1) To invite Sir William Perkin to be present at the American celebration as the guest of the Americans. (2) The presentation to Sir William Perkin of a personal token. (3) The foundation of a Perkin medal to be awarded annually to an American chemist for distinguished work in applied

chemistry. (4) The establishment of a nucleus of a fund for the foundation, at the Chemists' Club, in New York City of a reference and circulating library, covering the entire field of theoretical and applied chemistry, which is to be in charge of a salaried librarian and to contain duplicate sets, one of them to be used for circulation among American chemists.

It was estimated that $5,000 would be amply sufficient to cover the expenses of the personal token and the Perkin medal, while the sum of at least $50,000 would be necessary for placing the library on a permanent basis.

At the dinner the first Perkin medal and a silver tea service will be presented to Sir William Perkin, and there will be addresses on the development of the coal tar industry and after-dinner speeches.

SCIENTIFIC NOTES AND NEWS.

The Smithsonian Institution was represented by Mr. S. F. Emmons at the International Geological Congress held in Mexico City from the sixth to the fourteenth of the present month and by Dr. Walter Hough at the fifteenth International Congress of Americanists, held in Quebec from the tenth to the fifteenth. Dr. Hough also represented the U. S. National Museum.

Professor Wilhelm Hittorf, professor of physics at Münster, will be presented with a marble bust on the occasion of his jubilee, which will shortly be celebrated. Professor Hittorf has himself given 25,000 Marks for the scientific work in the Münster Academy.

Dr. Max Toepler, professor of physics at the Dresden Technological Institute, celebrated on September 7 his seventieth birthday.

Dr. A. R. Crook, for the past twelve years professor of mineralogy and economic geology at Northwestern University, has been appointed curator of the Illinois State Museum of Natural History at Springfield. During the past summer Professor Crook has visited museums of natural history in this country and abroad with a view to studying their methods of administration and installation.

Dr. Maynard M. Metcalf, professor of biology in the Woman's College in Baltimore since 1893, and now professor-elect of zoology in Oberlin College, has received the appointment to the Smithsonian seat in the Naples Zoological Station for the months of March and April, 1907. Dr. Stewart Paton, formerly of Johns Hopkins University, whom Dr. Metcalf succeeds at Naples, by extension of a former appointment, will occupy the Smithsonian seat for five months from the first of October of the present year. It is announced that the Smithsonian has decided to renew its lease of a table at the station for an additional term of three years from January 1, 1907, and that applications, which are acted on in order of receipt, may now be submitted. In view of the number of students who desire to avail themselves of this opportunity for study at Naples, a Smithsonian appointment is not approved for a longer period than six months, though in exceptional cases an extension may be asked for and granted, if such action does not interfere with the occupancy of other applicants.

The first meeting of the California Branch of the American Folk-Lore Society during 1906–07 was held September 11, at 8 P.M., in South Hall, University of California, Berkeley. Mr. Charles Keeler presided. On motion a nominating committee was appointed consisting of Professor Dresslar, Professor Fryer and Mrs. Dickson. The committee reported the following nominations for officers for 1906–07:

President—Charles Keeler.
First Vice-president—John Fryer.
Second Vice-president—W. F. Bade.
Treasurer—S. A. Barrett.
Secretary—A. L. Kroeber.
Councilors—Charles F. Lummis, W. C. Mitchell, Mrs. Thomas B. Bishop, John E. Matzke, C. Hart Merriam, E. J. Molera.

On motion the report of the committee was adopted, the nominees being thereby elected. Professor A. L. Kroeber thereupon gave an address on 'California Indian Myths and Songs,' illustrated by graphophone records.

We learn from *Nature* that the government of Cape Colony has placed a sum upon the

supplementary estimates toward the expenses incurred in carrying out investigations upon defects in ostrich feathers, under the direction of Professor J. E. Duerden, of Rhodes University College, Grahamstown.

THE New York *Evening Post* says: "Signor Giolitti, a son of the prime minister of Italy, accompanied by his wife, has arrived from Naples. He is a professor of mathematics, and has come to America to attend courses of lectures at some of the universities in this country."

MR. WELLMAN has arrived in Norway, on board the *Frithjof*, with his balloon, which will be sent to Paris for improvements to be made in the motor, which broke down constantly. The wireless apparatus which had been installed in Spitzbergen for communication with Hammerfest was also a failure, telegrams not having been received from Norway.

THE opening exercises of the 153d academic year of Columbia University were held on September 26. The annual academic address was delivered by W. H. Burr, professor of civil engineering, upon 'The Technical School and the University.' Professor Burr was followed by Dr. Hermann Schumacher, of the University of Bonn, first Kaiser Wilhelm professor of German history and institutions in Columbia University.

ON the evening of October 10 Professor C. J. Keyser, of Columbia University, will deliver a lecture on 'The Space Concept of Lucretius and Blaise Pascal' before the mathematical section of the Brooklyn Institute of Arts and Sciences.

DR. LUDWIG BOLTZMANN, eminent for his work in theoretical physics, of which subject he was professor in the University of Vienna, has committed suicide. He was born in Vienna in 1844, and after qualifying as docent at the university was successively professor at Gratz, Munich and Leipzig.

THE death is announced of Khan Bahadur Yusuf Sharif a Mohammedan geographer and topographer, who carried out important surveys in India and in Persia.

NEW YORK state civil service examinations will be held on October 13 for assistant bacteriologist in the State Department of Health at a salary of $1,500, and for assistant sanitary chemist in the same department at a salary of $720. There will also be an examination for the position of archeologist in the science division of the Educational Department at a salary of $900. This position requires an acquaintance with the Indian tribes of the state.

THE U. S. civil service commission announces an examination on October 17 for the position of engineer in the department of sewer and waterworks construction, Manila, at a salary of $4,000, and for the position of assistant engineers at salaries of $1,800.

AN arrangement has been made by Dr. Samuel G. Dixon, state commissioner of health in Pennsylvania and Dr. Allen J. Smith, professor of pathology in the University of Pennsylvania, by which the pathological laboratories of the Medical School shall be used by the state for bacteriological and other work. Dr. Herbert Fox has been put in charge of the work.

THE firm of Friedrich Krupp, Ltd., of Essen, plans the erection of a technico-physical laboratory at a cost of $500,000.

THE American Breeders' Association will hold its regular winter meeting at Columbus, Ohio, on January 15–18, 1907. The visiting association will conduct its daily sessions at the university and board of trade buildings as the guest of the Ohio Board of Agriculture, the Ohio State University and the Ohio agricultural societies. The most successful and foremost workers and investigators in breeding and heredity in animals and plants are being secured for the program. A prominent feature will be the reports from the forty-three committees among whom the work of the society is distributed. The American Breeders' Association has an annual membership of over 950 as well as 42 life members. Volume II., the second annual report, is just off the press.

ACCORDING to Reuter's Agency, the Indian government has under consideration a scheme

for reclaiming the Rann of Cutch, a work which, if carried out, will be similar to that undertaken by the Dutch in the Zuider Zee. The Rann of Cutch is a waste, at some seasons water, at others land, and it is proposed to reclaim it by closing the inlets from the sea, which are narrow. The water, which is everywhere shallow, would then evaporate rapidly, leaving heavy saline deposits. These, it is thought, could be washed out and drained away by a great canal to be constructed from the Indus. The application of scientific agriculture to the reclaimed land and the construction of a railway linking Karachi and Bombay would complete the proposed scheme.

UNIVERSITY AND EDUCATIONAL NEWS.

FOREIGN journals state that the Grecian government recently received from St. Petersburg a legacy of about eight million roubles (over $6,000,000), which was left in the beginning of the last century by a rich Grecian merchant, of the name of Dombolis, with the condition that after the lapse of a definite time a second Grecian university should be built in Corfu out of the capital and interest, and be called the Kapodistrias University.

WE learn from the *Journal of the American Medical Association* that the former professor of legal medicine and toxicology at Montpellier, France, Dr. Jaumes, who died recently, aged seventy-two, made the medical faculty his legatee. A fund producing an income of $1,200 was left to found a chair of general pathology and therapeutics, and a prize in legal medicine was also endowed in both the medical and law departments. Another fund representing an income of $2,000 reverts ultimately to the medical faculty, and $6,000 was presented to the local medical and other scientific societies.

MR. ALBERT CRANE, of Stamford, Connecticut, has given $100,000 to the Divinity School of Tufts College.

IMPROVEMENTS have been made during the summer at Cornell College which will greatly strengthen the scientific work. New and enlarged quarters have been provided for the engineering department and the departments of geology, physics and biology. Quantitative and organic laboratories have been provided for the chemical department. A large amount of apparatus has been secured for the different subjects.

A NEW dormitory for men has been erected at the University of the Pacific to replace the one damaged by the recent earthquake. It will contain fifty-six sleeping rooms (all outside rooms) each supplied with hot and cold water, fixtures for electric and gas light, and steam heat. Each floor will have six bath rooms and four needle-shower rooms with tile wainscoated sides and floors. The Y. M. C. A., library and club rooms will be 25 x 25 feet each. The building is being constructed of wood, steel and cement, with metal tile roof, will be practically fire-proof, and practically earthquake proof. It will cost about thirty thousand dollars. The fourth story of East Hall has been removed, the roof lowered and the entire building bound securely by steel rods. North, South, East, West, Central and Music Halls have been replastered and decorated. A new athletic field is being laid out, and a large plunge bath will be put in back of the gymnasium. One of the heating plants, destroyed by the earthquake, is being replaced by a large plant of sufficient capacity to heat all the buildings in place of two plants as at present.

THE buildings of Groningen University were partly destroyed by fire on August 30. The natural history museum and the chemical laboratories were among the buildings destroyed.

IT is reported that Zürich University will increase the lecture and laboratory fees chargeable to foreigners, with the idea of lessening their numbers.

DR. FRANCIS FRANCIS has been promoted to a chair of chemistry at University College, Bristol, vacant by the appointment of Dr. Travers to the directorship of the Indian Institute of Science, to be established at Bangalore.